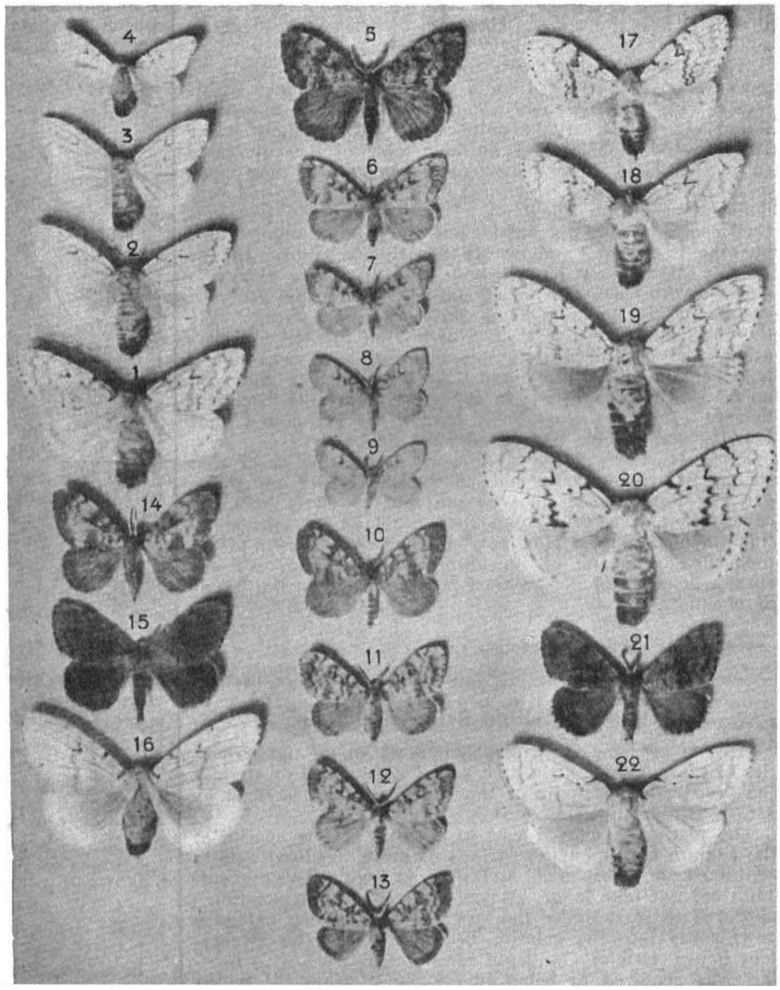
EXPERIMENTS ON VARIATIONS OF LEPIDOPTERA BY ENVIRONMENT.

AN important addition to the numerous papers of recent years recording experiments as to the influence upon the forms of living beings of their environment has lately been published.[1] In this paper the inquiry is concerned only or chiefly with varieties in the pigmentation of Lepidoptera. The author enumerates as among the agents to which change in this pigmentation is to be ascribed "intensity of light, temperature, nutrition, humidity, dryness, electricity, and other meteorological phenomena." His references to the literature on these subjects are very useful. The suggestion that mechanical movement, jarring, of pupæ, might cause effects analogous to those of temperature is mentioned, but this has long since been abandoned. M. Pictet divides the variation of pigmentation into two opposite types, the one "albinism," by which red can pass into yellow and even into white, the other "melanism," by which red passes into brown and, as an extreme, into black; and this classification is kept in view all through the description of his experiments and their results. So is a theory which he puts forward, though with diffidence, that caterpillars in general were originally adapted to live only on certain special plants or trees, and afterwards, owing to finding themselves, as the result of migration or otherwise, where these were not to be had, adapted themselves to many other kinds, so as to become more or less polyphagous, still, however, in nature attaching themselves by preference to special food plants, called in this paper their normal or ancestral ones.

M. Pictet's treatment of this subject can be best illustrated by an extract:—"*Lasiocampa quercus,* known from the time of Linnæus as feeding almost exclusively on the oak, as indeed its name indicates, and the leaves of some trees and hedge shrubs, is now found frequently on ivy, poplar, sallow, birch, heath and arbutus." He does not always say what the normal food plant is, as in the case of *Phalera bucephala,* of which he states that it absolutely refuses to eat any but its normal food. In England it is found on lime, elm, willow, and many other forest trees at least as freely as on oak, and there is a record of a company found on laurel. Oak is given as the normal food of *Biston hirtarius* (found in England on a great variety of forest trees), gooseberry and spindle tree (*Euonymus europaeus*) as those of *Abraxas grossulariata.* In England this species is found in abundance also on blackthorn, &c., and it has of late years addicted itself to the *Euonymus japonicus,* an evergreen which became widely distributed in Europe during the last century. Though, as stated, it is left uncertain in some cases what M. Pictet considers the normal food plants to be, that creates little or no difficulty in appreciating most of his experiments, as the kinds of food plants which in these experiments were substituted for the foods well known to be usual were so different that they may certainly be distinguished as abnormal; for example, when walnut or laurel, or low plants such as sainfoin (*Onobrychis sativa*), dandelion, lettuce, or salad burnet (*Poterium sanguisorba*) are substituted for any of the ordinary forest trees.



FIGS. 1 and 5.—*Ocneria dispar*, typical form ♀ and ♂; 2–4, 6–13, 17, 18, fed on walnut; 14 and 16, fed on mespilus; 15, fed on dandelion plants; 20 and 21, fed on onobrychis; 22, fed on poterium plants.

Among the principal conclusions arrived at by M. Pictet are the following:—(1) Change of ancestral food plant is often a factor of variability. (2) In general, a food difficult to absorb and digest prevents the larva from developing within its usual period, and this longer larval period is associated with the shortening of the pupal period, and consequently with insufficient pigmentation. (3) Normal food plant in insufficient quantity has the same effects. (4) A food easy to take in (ingérer) and rich in nutritious elements accelerates the larval development, and thus reacts on the duration of the pupal period, which, being thus lengthened, a more intense pigmentation

[1] "Influence de l'Alimentation et de l'Humidité sur la Variation des Papillons." By Arnold Pictet. (*Mémoires de la Société de Physique et d'Histoire naturelle de Genève*, vol. xxxv., fascicule 1, June, 1905, pp. 46–127.)

ensues. . . . (8) The variations produced by food increase in intensity with each generation, and even arrive at such a point as to persist to a degree, by heredity, in the next generation brought up on normal food; when, in successive generations, the food plant is different, each kind of food plant impresses its characteristic effects on the imago. (9) After some generations on the abnormal food the insect becomes accustomed to it, and this brings about a return to the primitive type—sometimes, indeed, passes beyond it in the opposite direction.

The experiments which led to these conclusions extended over five years, from 1900 to 1904, and were tried on 21 different species and about 4695 individuals. The paper is illustrated by five plates containing eighty-one photographic figures, which are excellent, but uncoloured, so that they have not the advantage of showing the distinctive colour effects which enter into the verbal description of the results obtained. The course of experiment can only be briefly indicated here, having due regard to the exigencies of space, but I may select for reference some of M. Pictet's chief experiments on what was their principal subject, *Ocneria dispar*; on this species there were twenty-nine experiments upon 1568 individuals. In many of those tried on this and other species the differences from the normal, so far as they are shown by the plates, are not very distinguishable from those deficiencies in intensity and definiteness of marking and the dwarfing of size that one is accustomed to find when larvæ are bred on food that is insufficient or unsuitable, to put it in a popular form, are "half starved." It is right, however, to say that M. Pictet considers, as afterwards mentioned, that in those examples which he has selected for illustration as exhibiting the effects of abnormal food plants, walnut, onobrychis, &c., they are distinguishable from each other to such an extent that where larvæ have been fed for three successive generations on walnut, onobrychis, and oak respectively, the special influences of all three food plants can be seen.

In six experiments with *O. dispar,* walnut was given for one or more generations; in all these cases the wing expansion was considerably smaller than normal, in some cases not more than three-quarters or two-thirds of it. Where *O. sativa,* dandelion or *P. sanguisorba* was given the imagines were considerably larger than normal, but when in one or more of the succeeding generations walnut was substituted the size was immediately reduced, much as in the other six experiments. *Mespilus germanicus,* horse chestnut, white poplar, and sallow had effects very similar to those of walnut. In experiment (4), where oak in the second generation succeeded walnut in the first, there was a slight return towards the type, but when in the third generation walnut was again given, the failure in intensity of markings reached its minimum, there being scarcely a trace of colour; when, however, in the fourth generation oak was again given, there was a nearer return towards the type than the second generation showed. In other cases the "albinistic" influence of the walnut persisted in a very marked degree after two later generations fed on oak or on *O. sativa.* In such cases, also, where other food plants of the three different classes ("albinising," "normal," and "melanising") had been given in succession, M. Pictet considers that the special pigmentation effects of each of the three kinds of food plant are shown by the imagines of the latest generation. These are for walnut, ♂, pale yellow colour, two central lines partly obliterated, other markings less intense; ♀, wings slightly transparent, few markings on upper wings, more on lower; second generation, ♂, wings whitish, marginal band on all partly obliterated, transverse lines little visible; ♀, wings transparent, the V mark and the marginal dots alone appearing; for *O. sativa,* ♂, wings brown, zigzag, lines little noticeable, marginal band very dark, abdominal hairs greyish; ♀, on upper wings white zigzag lines strongly marked; for *dandelion,* ♂, very similar, only the lower wings of uniform dark colour.

M. Pictet arrives at the general conclusion that the "albinising" variations are caused by the larvæ having been fed on leaves presenting obstacles to nutrition, such as hard cuticle or felted underside, as in white poplar, and that, on the other hand, the "melanising" variations are caused by food presenting no such obstacles; thus the young leaves of laurel are not "melanising" as the old leaves are. So far as I am aware, M. Pictet's conclusion that a difference of food plant in one generation can cause a difference of facies in the imago, and one that persists for several generations, is not in accordance with views hitherto prevailing; its bearing on the question whether a quality thus acquired can originate a new permanent variety or species is, however, at least materially affected by M. Pictet's other position, that where several generations have been brought up on the abnormal food so as to become accustomed to it, they revert towards the original form, so that there would appear to be only a temporary disturbance in the colouring of the species.

All M. Pictet's figures of *O. dispar* are reproduced as illustrative of this notice; those numbered 13 (walnut, oak, onobrychis), 14, and 16 (onobrychis, mespilus) are relied on by him as showing indications of each of the different food plants supplied to them and their ancestors, that numbered 10 (walnut, oak, walnut, walnut) as showing reversion towards the original normal form when the larvæ have for several generations been confined to abnormal food.

With respect to M. Pictet's position that an inverse rate of development in the pupa is caused by lengthening or shortening the duration of the larval "diapause" or period of repose, his experiments favour that view; but it will hardly be accepted as of general application without further experiments.

There is a section on the influence of food on the colour of the larvæ in which M. Pictet states that such an influence is exerted, with observations tending to show that in some cases there is a relation between the colour thus induced in the larva and the colouring of the imago. There are also experiments from which he draws the conclusion that the kind of food influences the secondary sexual characters of the larvæ which are so marked in *O. antiqua,* &c.; this does not, of course, mean that it changes the sex as has been asserted; on that he makes the just observation that it is not sufficient to count the respective numbers of males and females among the perfect insects obtained, but account ought also to be taken of those that die, usually in large numbers, and the male sex may be much more capable than the female of supporting the "tribulations of life," among which, one may add, must certainly be included scientific experiments on their food.

The second part of M. Pictet's paper is devoted to the influence of humidity. Excessive moisture applied to young larvæ is largely fatal, but seems to have no effect on the perfect insects which survive, beyond slightly reducing their size. Older larvæ, *i.e.* (usually) for the period of eight or ten days before pupation, resist it perfectly, but give "aberrations," some of which are figured, such as are met with here and there in nature.

The paper is a valuable contribution of facts to the solution of questions of much interest, and M. Pictet's conclusions as to the causes of the results he describes are well worthy of the consideration that they will doubtless receive. It is to be presumed that he took all proper means to isolate the influences he applied from other influences, but his arguments would perhaps have gained in force if he had stated in detail what steps he had taken to ensure this isolation. For example, in his experiments on the colouring assumed by larvæ, though he is acquainted with the experiments of Prof. Poulton and others, showing the undoubted effect of a few coloured surroundings on the colouring of the larvæ of many species, it does not appear what precautions were taken to exclude the operation of such surroundings; nor in the experiments on the duration of the pupal stage when the larval "diapause" was shortened, or in the humidity experiments, does it appear that the temperatures during all the time of the pupal stage were noted; it is known that a very moderate difference in temperature will make a difference of many days in the duration of this period. One may venture to suggest, also, that in the continuation which it is hoped M. Pictet will make of his valuable experiments he will give as far as possible the whole number of the insects in the broods at their commencements and the whole number of perfect insects reared—in the great majority of cases only percentages are given; also that he will state whether the whole or nearly the whole of those reared were similar in appearance to those figured, and whether there was any considerable proportion substantially different.

There appears to be one error to which, as it has not the character of a mere slip, and therefore has a bearing on the arguments used, it is necessary to direct attention. The larvæ of the first generation of the year of *V. urticae* are at p. 94 mentioned as coming from butterflies which "have probably passed the winter in the chrysalis stage," and at p. 81 "certain Vanessas" are spoken of as being able to pass the winter in the egg, chrysalis, or winter stage. Surely *V. urticae* hibernates only as an imago, wherever there is a real winter, as is the habit of the Vanessas generally. Again, fifteen to twenty days is stated as the usual period of the larval life of *Argynnis paphia*; in England this hibernates as a very young larva, and feeds up, very quickly it is true, during April, May, and June, appearing as an imago in July or early August, and this is its usual habit on the continent of Europe.

F. MERRIFIELD.

CHEMISTRY IN THE SERVICE OF THE STATE.[1]

IN the year 1840, the Legislature made an interesting fiscal experiment. It repealed all previous enactments against the adulteration of tobacco, and permitted any ingredients, "except the leaves of trees, herbs, and plants," to be added to that article in the course of its preparation. The result was that tobacco speedily became grossly adulterated; in two years the consumption had decreased by more than a million pounds; and, since tobacco is a heavily taxed commodity, the Exchequer suffered severely. So serious a loss had to be promptly stopped; hence in 1842 the prohibition of adulteration was re-enacted. To help in making the prohibition effective, the Commissioners of Inland Revenue fitted up a small laboratory, the staff of which, consisting for some time of one person only, was occupied solely in detecting fraudulent additions to tobacco.

[1] "Report of the Principal Chemist upon the Work of the Government Laboratory for the Year ending March 31, 1905" Official Publication, Cd. 2591. Price 3*d*.

Such was the modest origin of the chief branch of the institution which now undertakes nearly all the analytical and consultative chemical work required by the various Government departments. Another branch, the Customs Laboratory, may be said to owe its inception chiefly to the Sale of Food and Drugs Act, 1875, which laid upon the Board of Customs the duty of supervising the quality of imported tea. The two branches were affiliated in 1894 under one head.

How considerable the business of the laboratory has now become may be gathered from the recently issued report of the principal chemist, describing the work of the department during the last financial year. From this it appears that the number of samples analysed in that period was no less than 138,508. Of these, 49,751 were examined in the Customs branch, and the remainder, 88,757, in the main laboratory at Clement's Inn Passage.

What, however, more particularly strikes one is the wide range of interests, both of the State and of the individual, which are touched at one point or another by the chemical activities of the department. We extract from the report a few notes which may serve to illustrate this, and to indicate the nature of the questions dealt with.

Dealing first with the Customs, the ultimate aim of the various analyses is, of course, to facilitate the just assessments of Customs dues. This, however, involves the testing of many articles which are not themselves dutiable. For instance, genuine cider is free of duty. A temptation is thus offered to an unscrupulous wine importer, since by labelling his wine as "cider" he may, if undetected, get it passed into the country without payment. As a matter of fact, out of 154 samples examined during the past year, 10 represented importations of so-called "cider" which was found to be chargeable as wine, and another had to pay duty as a spirit preparation. Again, crude methyl alcohol is admitted free, but if purified so as to be potable must pay the spirit duty. In 31 cases out of 256 the substance was, in fact, so pure that the full alcohol rate was levied.

As compared with the previous year, there has been a notable decrease in the number of certain beer, wine, and liqueur samples; this is attributed to diminished consumption of alcoholic beverages. On the other hand, samples of tea show a considerable increase—from 2345 to 3260—in spite of an augmented tea-duty. For various reasons, 316 of these specimens of tea were objected to, and 7 were condemned as unfit for human food.

Among other items of interest, we note that facilities are given by the Customs authorities for the utilising of waste tobacco in the preparation of sheep dips and similar articles. It appears that nicotine is supplanting arsenic as the active principle in such products.

The very high duty on saccharin—20*s*. per pound—involves, the principal chemist remarks, a careful outlook for this substance in the most unlikely places. 617 samples of articles which might have been vehicles for its fraudulent introduction were tested, and 55 of the number were charged the duty as being either saccharin or substances of like nature and use.

In the laboratory at Clement's Inn Passage, the business is classed as (1) Revenue work; (2) work for other Government departments; and (3) the analysis of samples referred by magistrates to the Government chemists in disputed cases under the Sale of Food and Drugs Acts. The examinations of excisable articles are devised to secure the revenue accruing from beer,